TERRA Transportation Engineering and Road Research Alliance

Partnering for Roadway Innovation

January 2010

www.TerraRoadAlliance.org

Impacts of Heavy Farm Equipment on Rural Roads

Preliminary results of a TERRA pooled-fund study

Over the past few decades, farms have consolidated and farm size has increased significantly. The farm equipment industry has responded by producing larger and heavier equipment. For example, it is not unusual to see liquid manure application equipment that hauls 9,000 gallons or more. Innovations such as steerable axles, flotation tires (spreading the load over a much larger area), and new tire designs have been implemented on the equipment in recent years. The length, width, and axle loads of the large equipment could potentially accelerate damage on roads. However, there is insufficient data to show the effects of the equipment on pavement response and performance.

Pooled-Fund Study

A TERRA-initiated research study through the FHWA Transportation Pooled Fund, Effects of Implements of Husbandry "Farm Equipment" on Pavement Performance, TPF-5(148), was begun in 2008 to study pavement response under selected agricultural equipment and a typical 5-axle semi-trailer truck. Two sections of a specially constructed "farm loop" test track at MnROAD were instrumented with different types of electronic sensors to measure pavement responses, such as stress and strain. One section, with 5.5 inches of hot-mix asphalt (HMA) and a 9-inch gravel base, represents a typical 10-ton road. The other, with 3.5 inches of HMA and 8 inches of gravel, is a typical 7-ton road.

The main objectives of this pooled-fund project:

- Determine the pavement response under various types of agricultural equipment (including the impacts of different tires and additional axles) using instrumented pavements at MnROAD.
- Compare the pavement response under farm equipment to the pavement response under a typical 5-axle semi tractor-trailer and determine the damage caused by farm equipment, if any.

This pooled-fund project includes contributions from Iowa DOT, Illinois DOT, Wisconsin DOT, the Minnesota Local Road Research Board (LRRB), the Professional Nutrient Applicators Association of Wisconsin (PNAAW), and Mn/DOT. Many industry partners, including equipment and tire manufacturers and farm applicators, are participating in the project and contributing equipment and labor.

The pooled-fund project will conclude in fall 2011.

Preliminary Results

Researchers tested farm equipment and a 5-axle semi on two sections of the MnROAD farm loop. Earlier test results in spring and fall 2008 demonstrated that axle load has a pronounced effect on pavement stress—the stress increased with axle load. For flotation tires, the pavement-tire contact area increased with load. The data also indicated that the bottom of a pavement could undergo fatigue from tension to compression depending on wheel location.

In spring 2009, researchers observed extensive rutting on the 7-ton section, which is paved with a thinner layer of asphalt. This failure illustrates the importance of spring load restrictions for this type of pavement. During fall 2009 testing, more damage was detected on another part of the 7-ton section. These preliminary findings suggest that this type of pavement is not strong enough to support repeated applications of heavy loads.

The MnROAD "farm loop"

For this study, an entirely new road was built at MnROAD, the "farm loop." The test roadway, constructed in 2007, is typical of many rural, low-volume county roads. One section represented a typical 7-ton road and the other represented a typical 10-ton road.

Testing with several different vehicles has been conducted in the spring and fall seasons since 2008 to capture the seasonal variation in pavement strength and response to heavy loading. So far, 9 vehicles, of a proposed 17 total, have been tested.

The existence of a separate test section allows researchers to reconstruct the road as often as needed for testing. Because heavier and wider farm equipment comes out every year, MnROAD hopes to use the farm loop as a national center for testing overweight vehicles from farming and other industries long after this project is complete.

Next Steps

Three more cycles of testing are planned, in spring and fall of 2010 and spring 2011. The key objective of the final rounds of testing is to collect more data. The results and findings will be updated as more data are collected and analyzed.

Background

In 2001, responding to industry concerns, the Minnesota Department of Transportation (Mn/DOT) conducted a scoping study on the impact of agricultural equipment on Minnesota's low-volume roads. The study reviewed several county roads where damage was suspected from farm equipment. However, the study found that other heavy vehicles, such as trucks hauling gravel or rock from quarries, also might have contributed to the damage. One of the recommendations from the study was to conduct a field investigation at MnROAD to specifically address pavement damage due to agricultural equipment.

A 2005 synthesis study by Mn/DOT, building on research conducted by the South Dakota and Iowa DOTs, found that there is a significant body of quantitative information validating the detrimental effects of heavy agricultural equipment on local roads. Generally, implements of husbandry can be characterized as being heavy, having large transverse tire spacing, and being slow-moving, the study found. All three of these characteristics have considerable adverse effects on the performance of roadway pavements.

Degradation of pavements has been specifically linked by numerous researchers to three common attributes of farm equipment:

- **exceeding the 20,000-pound single-axle** weight limit
- **having wide transverse tire spacing**(s), which places heavy loads on pavement edges that can become critically stressed (this phenomenon can decrease the design life of rigid pavements by up to 20 times)
- **moving slowly**, which increases the load duration, exacerbating rutting (permanent deformations) in flexible pavements

For Further Reading

- Effects of Implements of Husbandry "Farm Equipment" on Pavement Performance, TPF-5(148) pooled-fund project
- *TERRA E-News* reports about the farm implements project
- *Response of Iowa Pavements to a Tracked Agricultural Vehicle* (CTRE report, December 2000)
- *Impact of Agricultural Equipment on Minnesota's Low Volume Roads* (Mn/DOT scoping study, January 2001)
- *Impacts of Overweight Implements of Husbandry on Minnesota Roads and Bridges* (Mn/DOT report, 2005)
- "Vehicle Weight Exemption: Boon or Bust" (Minnesota Counties, September 2004)
- *Effects of Off-Road Equipment on Flexible Pavements* (SDLTAP Special Bulletin No. 44, 2002)
- *Heavy Agricultural Loads on Pavements and Bridges* (ISU Engineering Research Institute report, March 1999)

Links to these resources are on the TERRA Web site at www.TerraRoadAlliance.org.

For More Information

For more information about the research in this fact sheet, please contact:

- Shongtao Dai, Ph.D., P.E., research operations engineer, Minnesota Department of Transportation, 651-366-5407, Shongtao.Dai@state.mn.us.

Participants

- Minnesota Local Road Research Board (LRRB)
- Minnesota Department of Transportation
- Illinois Department of Transportation
- Iowa Department of Transportation
- Wisconsin Department of Transportation
- University of Minnesota
- Industry representatives, including equipment providers

About TERRA

The Transportation Engineering and Road Research Alliance, or TERRA, brings together government, industry, and academia in a dynamic partnership to advance innovations in road engineering and construction, including issues related to cold climates. More about TERRA is online at www.TerraRoadAlliance.org.

For more about TERRA, please contact:

- Laurie McGinnis, Acting Director, Center for Transportation Studies, University of Minnesota, 612-625-3019, mcgin001@ umn.edu
- Maureen Jensen, Manager, Road Research Section, Office of Materials, Minnesota Department of Transportation, 651-366-5507, maureen.jensen@state.mn.us